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Computation of baseline emissions of greenhouse gases and future projections for the transport sector in the State of Veracruz, México

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Abstract: Transport is the largest and fastest-growing sector in terms of energy consumption and GHG -greenhouse gas- emissions. The sector consists of the road, air, rail, and water transport subsectors. The baseline or trend scenario is a reasonable projection of GHG emissions that would occur in the absence of mitigation actions. The baseline scenario is a key input for the design of component GHG emissions mitigation through interventions that can be included: raising energy-efficiency standards for new vehicles, optimizing transportation routes, creating a bus rapid transit (BRT) system, encouraging non-motorized transport, mandating the inspection and maintenance of in-use, imposing import restrictions on vehicles through inspection, coordinating road freight, and promoting freight trains.

The calculation of baseline GHG emissions for the transport sector is an opportunity under the Climate Action Program of the State of Veracruz. The transport sector is facing significant challenges in the state, because it is one of the sectors with the highest percentage (20.9%) contribution of GHG emissions from Veracruz. The baseline scenario was generated using the LEAP (Long-range Energy Alternatives Planning) model, based on macroeconomic assumptions for GDP, population growth, and fuel consumptions. Under the baseline scenario, total CO_2e emissions are estimated to grow from 10 Mt in 2010 to 14.7 Mt in 2030. Reducing greenhouse gas emissions is critical in Veracruz, not only to address climate change but also to facilitate economic development, a key emphasis of the México's climate change agenda.

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Introduction

Climate change poses two fundamental challenges for the transport sector: transport will have to significantly reduce greenhouse gas (GHG) emissions and it will require investment in order to adapt to impacts of climate change.

According to an OECD study on transport (OECD/ITF, 2009) the world vehicle fleet is currently dominated by internal combustion engines (ICE's). It is likely that over the next 10-25 years this domination will continue as both gasoline-powered spark ignition and diesel powered compression ignition engines are further improved for energy efficiency. There is a clear opportunity to improve new car fuel economy 30% or more by 2020 and 50% by 2030 worldwide, in a cost-effective manner (e.g. low or negative cost per ton of CO_2).

The Fifth National Communication to the United Nations Framework Convention on Climate Change, (SEMARNAT-INE, 2012) pointed that transport sector is one the main source for GHG emission in México and it accounts for 33% of the nation's greenhouse gas emissions. As regards the distribution of end-use consumption of energy by sector, from 1990 to 2010 the transport sector had an on-going growth in its share of

energyusage.GHG emissions in Mexico are expected to rise and the sectors with the highest GHG growth and emissions will be electricity generation and transportation. It is important to stress that establishing a baseline provides a reference for planning and represents an estimated projection. There has been some research on GHG emission projection in the transport sector in the provinces of México. The main research has been developed at federal level. For example a study related to Low Carbon Emissions of Mexico, various scenarios were valuated using the LEAP model to estimating a baseline CO_2e emission by transport mode from 2008 to 2030.(Johnson, T.M. and et al, 2009).

The Veracruz Program on Climate Change (Programa Veracruzano ante el Cambia Climático, PVCC) was concluded in 2008 and made available to the public in March 2009.The fundamental purpose of the PVCC is to provide trust worthy information to Veracruz's society and decision-makers, so that they can understand the phenomenon of climate change and its possible consequences in the state. The PVCC has reported that the mitigation potential for Veracruz's transport sector could have high potential to promote mitigation measures. (Martinez 2009).The National Program for Sustainable Energy Use 2009-2012 (PRONASE, Spanish acronym), identifies energy efficiency opportunities for short, medium and long-term savings with seven priority areas, one of them is transport. (SENER/CONUE, 2012).

This study focus on estimation of baseline GHG emissions and future projections for the transport sector in the State of Veracruz, the reason to choose Veracruz State as the research objective can be stated in two aspects. On the one hand, Veracruz State is a representative state of the country in terms of economic, environmental and social issues. On the other hand, the State of Veracruz is the first state in Mexico to implement a climate change mitigation and adaptation program. The Veracruz Program against Climate Change (PEACC, for its acronomyin Spanish) and the subsequent State Law on Mitigation and Adaptation to Climate Change Effects is pivotal in promoting actions to address climate change and protecting vulnerable groups at the local level, so Veracruz is one of the states that is rated for an advanced level in terms of the climate change strategies (USAID, 2012). Therefore, it is necessary to research the baseline GHG emissions in the sector transport and others.

Veracruz´s transport sector status.

Transport is the largest and fastest-growing sector in Veracruz in terms of energy consumption and greenhouse gas emissions. The sector consists of the road, air, rail, and maritime transport subsectors. Regards Veracruz State Greenhouses Gases Inventory 2010, the principal fuels used in the transport sector is showed in the Table 1. Fuel consumption under the transport sector are itemized as follows: gasoline, 10.5.0% (80,600 TJ); diesel (road transport), 9.8% (75,400 TJ); diesel (rail transport) 5.8% (44,800 TJ); diesel (maritime transport), 0.4% (3,000 TJ); jet fuel 0.6 % and LPG 0.2 %.

Table 1. Fuel consumption under transport sector

Fuel	Energy consumption		
	Million of ft^3	Millions of barrels	TJ
Gasoline	88.7	15.8	80,600
Diesel (road transport)	83.0	14.8	75,400
Diesel (rail transport)	44.2	7.9	44,800
Diesel (maritime transport)	4.6	0.5	3,000
Jet fuel	6.0	0.8	4,600
LPG	2.4	0.4	5,900
TOTAL	**148.8**	**25.5**	**140,700**

Source: Veracruz State Greenhouses Gases Inventory 2010

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Fuel demand trends

According to Energy information System (SIE, acronomy in Spanish) and the oil prospective 2012-2026 for Mexico is predicted based on the trend analysis of economic development for different regions of the country, as the south-southeast region, where Veracruz is located. The average annual growth rate of Veracruz's gasoline demand was 5.7 % from 2000 to 2011; diesel demand in the same period was 2.4%; and jet fuel was 3.1 %. The average demand for Mexico is itemized as follow: gasoline 3.8 %; diesel 2.8 % and the jet fuel 0.1 %.(SENER, 2012).

As regards the foresight of oil products in South-east region, Veracruz requires the largest volume of gasoline, to 79.8 mbd. Throughout the prospective period is estimated a mean increase of 4.1%.

It is important to point out, that the most important in characterizing fuel demand factor of the transport sector is the vehicle fleet. The greater the number of units reported categories of compact and lightweight. It is expected, between 2011 and 2026, an increase of 6.6% in annual average gasoline vehicle fleet. This will result in an average annual growth of 3.7% in the demand for fuel in the trucking sector.

As the demand for automotive gasoline vehicle segment, it is estimated that mixed use loading and consume 58.9% of that in 2026. Thus, during the period 2011-2026 an average annual growth of 4.4% was recorded. It is also estimated that the consumption of the compact vehicles amounts to 242.9 thousand barrels per day in 2026, it is around 17.7% of the demand of the trucking sector. During the prospective period, its average annual growth will be 2.7%. Meanwhile, consumption of subcompact vehicles, which participate with 10.8%, 1.8% averages grow year, reaching 147.6 thousand barrels at the end of the prospective period. The rest corresponds to the consumption of luxury and sports cars, motorcycles and light.

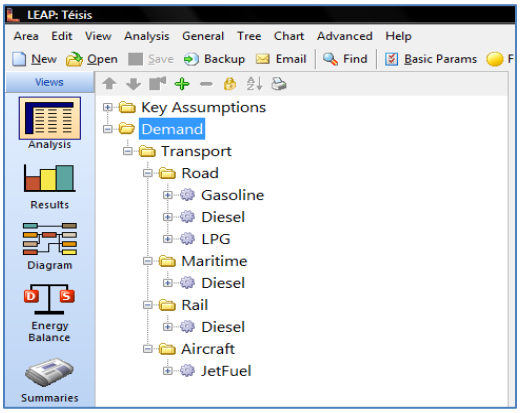
Materials and methods

The projection analysis used the Long-Range energy Alternatives Planning System (LEAP, 2007) Model and examined the sector transport emissions. LEAP is a scenario-based energy-environment modeling tool based on comprehensive accounting of how energy is consumed in a given region or economy under a range of alternatives assumptions. The base year used in this analysis is 2010-the same year used for compilation of the state GHG inventory. The first projection year was 2011 and the last 2030. Historical data were used in the so called Current Account (LEAP model terminology). Projections for the year 2010 to 2030 were made for a scenario: the reference scenario.

The input data for the LEAP model were grouped into two categories called modules.

Key assumptions	Macroeconomic and other time-series variables Prospective of Oil in México 2012-2026
Demand	Fuel consumption for each transport subsector

The subcategories or branches in each of these modules were determined by the level of detailed data that were available. The subcategories in the model-LEAP are shown as follow:



Estimates of fuel consumption and hence GHG emissions from the transport sector require data for the annual estimates average consumption in

Veracruz. Consumption from different subsectors was based on data compiled in the recent GHG emissions inventory for Veracruz.

Energy use in the transportation sector includes energy consumed in moving people and goods by road, rail, air and water. Transportation systems are essential for trade and economic competitiveness in an increasingly globalized world, as well as for enhancing standards of living. Trade and economic activity are the most significant factors determining demand for freight transportation. A more complex set of determinants—including travel behavior, land use patterns, and urbanization—affect demand for passenger transportation, along with macroeconomic and fuel market impacts

In this study-case, Veracruz energy consumption in the transportation sector increases by an average of 0.7 percent per year. Gasoline and Diesel are the most important fuel used for of transportation. The consumption projection by fuel in the transport sectors showed in the Table 2 in Peta Joules units.

Table 2. Fuel consumption projection

Fuel consumption (PJ)	2010	2015	2020	2025	2030
Diesel	52.4	52.4	52.4	52.4	52.4
Gasoline	80.6	100.6	124.3	144.6	148.6
Kerosene	5.9	4.3	5	5.7	5.9
LPG	1.8	2	2	2	2
Total	140.7	159.3	183.7	204.7	209

Source: own creation-LEAP

Results and Discussion

Figure 1, illustrates the greenhouse gas emissions. It can be seen that the greenhouse gas emission continues to increase from 2010 to 2030. Baseline scenario represents the most conservative greenhouse gas emission projection. In the baseline scenario, the key assumption is that no measures will be implemented during the scenario period; therefore, the baseline scenario provides a reference vision of how energy demand and GHG emissions in the sector transport of Veracruz State would evolve if the state government does nothing to influence long-term trends. The model indicates that if keeping the development tendency, from 2010 to 2030, there is likely to be 63,457 Mt CO_2eq emitting from Veracruz's transport sector during the projection period. Emissions under the transport sector in 2010 are itemized as follows: road transport, 90.1%; maritime transport, 3.4%; rail transport, 2.2 %; aircraft transport, 4.2%.Figure 1 shows the projection of the baseline sample and a growing trend of GHG emissions is observed by subsector.

Figure 1. Projections of GHG by subsector in M CO_2e

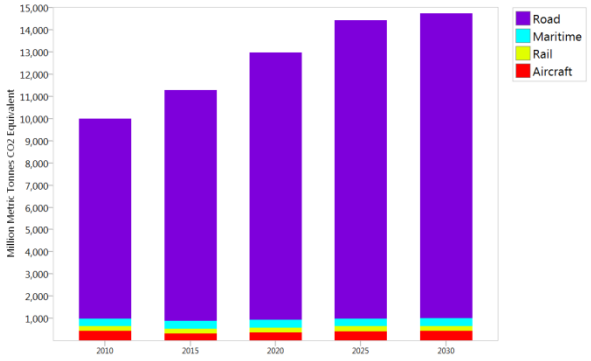
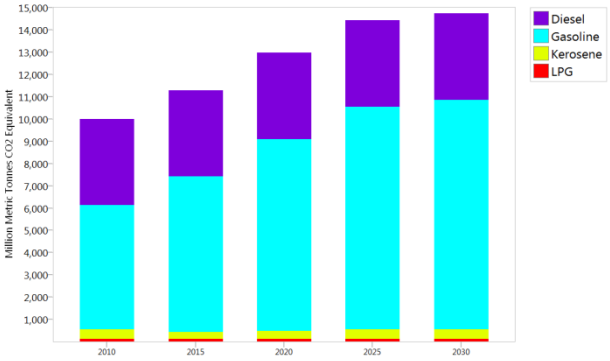


Figure 2. Projections of GHG by subsector in MtCO_2e



The main contributions correspond to trucking (road transport), which corresponds to fuels: gasoline and diesel as is showed in Figure 2. As displayed in Figure 1 and Figure 2, the road

transport in 2010 emitted almost all of total GHG emissions of Veracruz. Also displayed in Table 2 is the energy-related CO_2 emissions split by consumption fuel. CO_2 emissions resulting from gasoline combustion make up 55.8 percent of energy-related CO_2 emissions, more than diesel (38.8 percent), jet fuel (4.2 percent) and LPG (1.1 percent). Figure 2 displays GHG emissions projections in the Veracruz. By 2010, emissions are projected to rise to about 10,006 million metric tons of carbon dioxide equivalent per year (10,006 MtCO2e/year). By 2030, emissions are projected to rise to about14, 736MtCO2e/year. Projected GHG emissions in 2010 and 2030 are 47 percent higher than 2010baseline emissions.

Conclusion

The GHG baselines scenarios are fundamental tools for policy-makers to set up action plans to mitigate GHG emissions. This paper conducted a study about a scenario of greenhouse gas emissions in the transport sector of Veracruz State. The LEAP model was used to estimated de baseline and projections of GHG emissions to 2030. The main conclusions are summarized as follows: There is a potential of GHG emission reduction in Veracruz's transport sector. In terms of emissions, in 2030 could be reach 14,736 $MtCO_2e$ more than the baseline scenario.

The road transport is the main subsector in consumption of gasoline and diesel with 55.8% and 38.8% respectively. Regarding to the sub-sectors: maritime, rail and air; the road transport consumes 90.1% of the overall transport sector. Therefore, this consumption is translated into GHG emissions, which is mainly from road transport subsector and the fuel consumption is gasoline and diesel.

It is recommended, Veracruz can develop Low Emissions Development-LEDs strategies to achieve local sustainable development. Local Appropriate Mitigation Actions could allow implementing interventions to reduce GHG emissions as: public transport and vehicle efficiency, urban densification, bus rapid transit systems, non-motorized transport, bus system optimization vehicle fuel economy standards, vehicle inspection, road freight logistics or railway freight. Implementation of the aforementioned interventions faces political, financial, and social barriers. An important consideration for the optimization of urban transportation systems is the coordination between agencies working on environment, urban planning, and transport issues, as well as across different levels of governments.

It is noteworthy that this study was held with the information available in the inventory of emissions of greenhouse gases in the State of Veracruz, so it could be recommended a bottom-up approach focusing at municipal level instead of state, and include local parameters relating to fleet, driving patterns, medium trips, average vehicle speed and the fuel consumption.

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